William J. Rogers

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FM 1-35

WAR DEPARTMENT

AIR CORPS FIELD MANUAL

AERIAL PHOTOGRAPHY

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AERIAL PHOTOGRAPHY

Prepared under direction of the
Chief of the Air Corps

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1941

WAR DEPARTMENT,
WASHINGTON, *December 20, 1940.*

FM 1–35, Air Corps Field Manual, Aerial Photography, is published for the information and guidance of all concerned.

[A. G. 062.11 (9–30–40).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

E. S. ADAMS,
Major General,
The Adjutant General.

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AIR CORPS FIELD MANUAL

AERIAL PHOTOGRAPHY

CHAPTER 1

AERIAL PHOTOGRAPHS FOR MILITARY PURPOSES

SECTION I

GENERAL

■ 1. SCOPE.—This manual sets forth the nature, types, and purposes of aerial photography with its application to military requirements. The Air Corps functions with respect to aerial photography and the factors affecting the execution of these functions are developed. Methods and operative technique required in the performance of various types of missions are also prescribed. Appendix I lists terms of special application to aerial photography.

■ 2. REFERENCES.—*a*. There are many complex items of equipment used in photographic processes which will not be specifically mentioned in this manual, as they are comprehensively discussed in the number ten series of Technical Orders. Pertinent Technical Orders will be consulted whenever details of operation or maintenance of equipment are needed.

b. Other pertinent references regarding tactical employment and basic information on photography and the several processes pertaining to it are listed in appendix II.

SECTION II

DESCRIPTION OF AERIAL PHOTOGRAPHS

■ 3. GENERAL.—An aerial photograph is a perspective picture, with either a vertical or an oblique viewpoint, taken from an aircraft. Except for color values and a certain capacity of the eyes to perceive differences in relief, the black

and white aerial photograph conveys the same impression in image as received by the human eye from the same viewpoint. Since the average person is unaccustomed to the vertical viewpoint, the images of familiar objects on photographs may at first appear strange and unassociated with the objects represented. The difficulties presented in interpretation of vertical aerial photographs appear to be no greater than those ordinarily encountered in learning to read conventional military maps and are overcome in the same way.

■ 4. CAMERA TYPES.—*a*. Aerial photographs used for military purposes are made with various types of Air Corps cameras. In general these types are—

(1) A fully automatic aircraft camera for photographic reconnaissance and photographic mapping. Example: Type K–3B.

(2) An aircraft camera for high altitude, large scale photographic reconnaissance. Example: K–7C.

(3) An aircraft camera, single lens, with between-lens shutter to take aerial photographs at night. Example: Type K–12.

(4) An aircraft five-lens camera covering a total included angle of 140° for precise photographic mapping. Example: T–3A.

b. For a full description and use of Air Corps cameras see * TM 1–220 and Air Corps technical instructions for each type.

c. The photographs made with Air Corps cameras are classified as verticals, obliques, and composites.

■ 5. VERTICALS.—*a*. The term vertical is applied to all those photographs obtained by pointing a single-lens camera, at instant of exposure, so that the optical axis is as nearly vertical as possible. This type is the most useful for general military purposes. Figure 1 illustrates a vertical photograph. The area shown on this photograph is represented within the rectangle in figure 3. The camera film is practically horizontal at exposure, hence features on the ground are registered on a vertical photograph in vertical aspect with negligible distortion in their horizontal dimensions.

* See appendix II.

b. The vertical aerial photograph is a valuable instrument for conveying topographic information and has the following advantages:

(1) It possesses in pictorial effect a wealth of detail which no map can equal.

(2) It possesses accuracy of form.

(3) With freedom of flight, an aerial photograph may be prepared in a short time.

(4) It may be reproduced in quantity by lithography.



FIGURE 1.—Vertical photograph of rectangular area shown in figure 3.

(5) It may be made of an area otherwise inaccessible because of either physical or military reasons.

c. The vertical photograph is inferior to a map in respect to the following features:

(1) Important military features which are emphasized on a map are sometimes obscured or hidden by the other detail.

(2) Relative relief is not readily apparent.

(3) Displacements of position caused by relief and camera tilt usually do not permit the accurate determination of either distance or direction.



FIGURE 2.—Oblique photograph of area shown by trapezoid of figure 3.

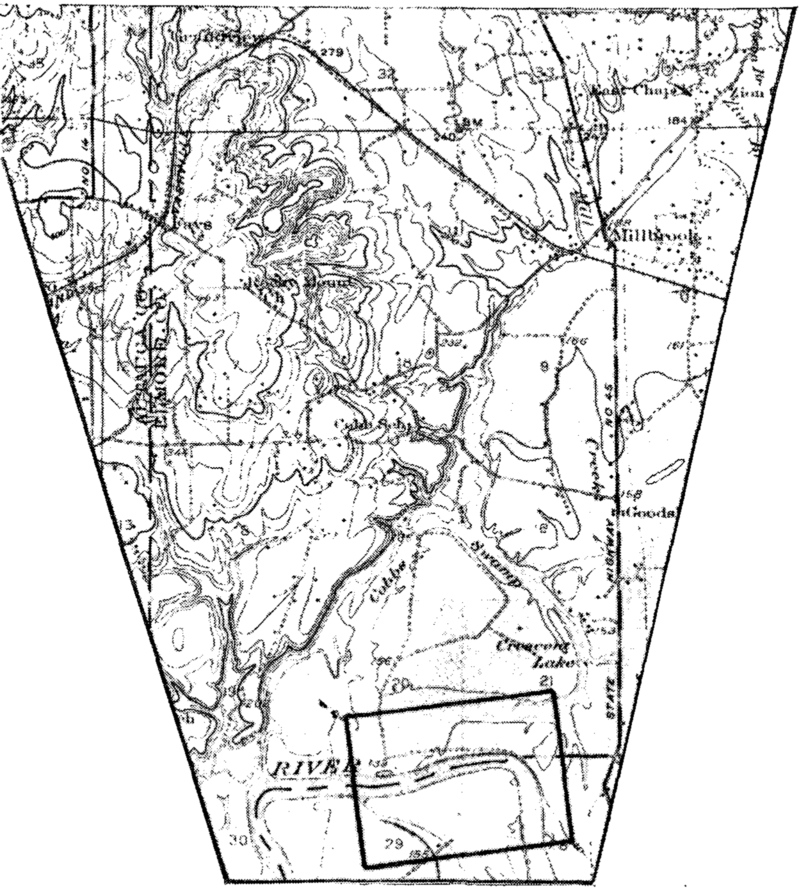


FIGURE 3.—Rectangular area in foreground indicates coverage of vertical photograph of figure 1. Entire trapezoid shows coverage of oblique photograph of figure 2.

(4) Because of a lack of contrast in tone, it is difficult to read in poor light.

■ 6. OBLIQUES.—*a.* Oblique aerial photographs are obtained by intentionally tilting the optical axis of the camera from the vertical. Figure 2 is a reproduction of an oblique photograph. This oblique photograph covers an area represented by the trapezoidal section of the map marked as figure 3. The oblique photograph is rectangular in shape, but the area of ground photographed is a trapezoid (fig. 4). An oblique photograph which includes the horizon is classified as a *high oblique.* One which does not include the horizon is called a *low oblique.* (See fig. 5.)

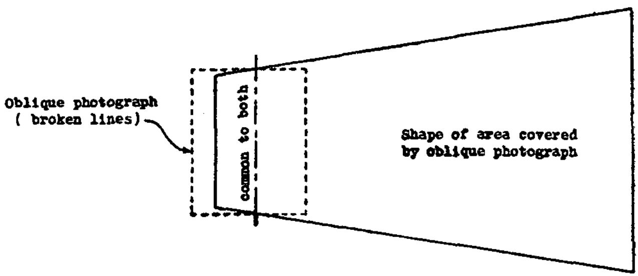


FIGURE 4.—Scale relation of area covered by oblique photograph to photograph itself.

b. Oblique photographs are useful in emphasizing ground forms, in studying vertical dimensions of terrain features or works of man, or in interpreting detail not easily distinguished on vertical photographs. They are used primarily as a substitute for a vertical photograph. It is frequently possible to secure oblique photographs of an area or object when, because of weather conditions or enemy activity, vertical photography is impracticable. Oblique photographs are very useful in revealing the details of construction of bridges, dams, locks, buildings, and other works of man. They are also useful in disclosing to the soldier untrained in map reading a panoramic view of terrain over which he may be expected to operate.

■ 7. COMPOSITES.—*a.* A composite photograph is one made by joining several photographs transformed to a common

plane which have been taken at a single camera position. Vertical composites are made with the Air Corps T-3A type multiple-lens camera. This camera has one central cham-

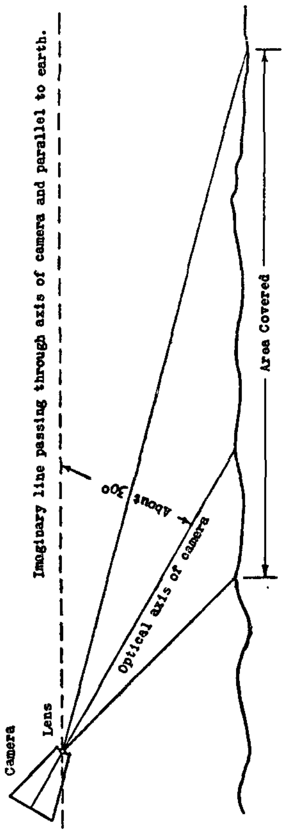


FIGURE 5.—Position of aerial camera at exposure of oblique photograph (diagrammatic).

ber, the optical axis of which is held in a vertical position at exposure, and four peripheral chambers, the lenses of which are inclined at an angle of 43° with the central lens. The camera has a focal length of 150 millimeters (approxi-

mately 6 inches). The result of a single exposure with this camera is one plain vertical photograph which trims to 5.4 by 5.4 inches and four obliques (called wing photographs) which are transformed to the plane of the center photograph, joined to it, and mounted to produce a single photograph in the shape of a Maltese cross approximately 32 by 32 inches.

b. The transformation of the wing photographs to the plane of the center photograph is effected by means of a transforming printer which projects the wing negatives to print paper which is inclined at an angle corresponding to the lens inclination in the T–3A camera. The lens of a transforming printer is calibrated to match those of an individual T–3A camera. Calibration requires time, and usually an individual camera has only one printer capable of transforming the oblique negatives.

c. Because of the wide angular scope of 140° and the short focal length of the T–3A camera, a single photograph from a relatively low altitude will cover an area of great width. For example, a single exposure at 18,000 feet altitude gives a picture of an area approximately 18 by 18 miles in dimension. It is this feature which makes this camera particularly adaptable to military mapping and to exploiting the detail of a large expanse of terrain from a single photograph.

d. It has also been found possible to make a nine-lens composite by taking two pictures with T–3A cameras when one camera is rotated about its vertical axis to place the fore-and-aft axis of the two at 45° to each other, thus using the wing photographs of one composite to fill the voids of the other. A photograph of a large area can be produced much more quickly by this method than by the construction of a mosaic.

■ 8. QUICK WORK AERIAL PHOTOGRAPHY.—This type of photography is under development for the adjustment of medium and heavy artillery fire. A special type camera producing a print approximately 5 by 7 inches is being developed for this purpose.

a. Preliminary photograph.—The use of the camera to adjust artillery fire requires that a recent vertical photograph covering the area of the target be available to the battery commander or those adjusting fire.

b. Procedure.—Aerial artillery adjustment methods are prescribed in FM 1–20 and TM 6–210. The cameraman processes, in the airplane, a special type of developing-out paper used in making the exposure. The equipment used is compact and permits the processing and dropping of a print at the battery position within a few minutes after exposure. The print dropped at the battery is the only copy of that photograph made, since the method employed does not produce a negative from which additional photographs may be made.

■ 9. CINEMATOGRAPHY.—The role to be played by aerial cinematography in military operations cannot be definitely stated. Technically the aerial motion-picture camera is capable of performing any of the aerial photographic missions listed elsewhere in this manual. At present it is employed in connection with training films, publicity releases, and technical studies of equipment undergoing test.

■ 10. DATA PERTAINING TO AERIAL PHOTOGRAPHS.—*a.* The following information appears on the margin of a photograph:

(1) *Index number.*—An index number appears on each photograph. This number identifies the picture in the series or flight to which it pertains.

(2) *Collimating marks.*—A template is accurately mounted in each camera in such manner that a sharp line is registered on each margin of the negative. This line appears on the print as one side of a small triangle and is called a *collimating mark.* The intersection of two straight lines connecting opposite collimating marks is termed the principal point or intersection of lens axis with the focal plane. The principal point is the approximate center of the contact print.

b. In addition to the information contained in *a* above, the negatives must be titled in a manner to make them intelligible to ground troops. FM 30–21 prescribes the method of titling and the information to be included.

■ 11. PRINT PAPER.—Photographs may be printed on glossy, matte, or semimatte paper of single or double weight. Glossy paper gives clearest definition of detail, but will receive marks

or notations only in ink. Light matte paper shrinks badly and lacks sharpness of detail, but will receive either pencil or ink marks. Double-weight semimatte paper of best quality has low shrinkage, will receive pencil marks, may be used unmounted, and has clearer definition of detail than matte paper of the same weight. Changes in temperature and moisture cause glazed print paper to curl up and become refractory. In general, all prints intended for extensive use should be mounted on manila or similar paper with rubber cement. To reduce shrinkage, photographs used on mapping projects are mounted on heavy cardboard or on thin metal sheets.

■ 12. OVERLAYS.—*a.* Not only is it difficult to mark on the face of a glossy photograph, but marks on the face of any photograph tend to clutter it up, obscure important detail, and diminish its usefulness. Yet it is sometimes desirable that positions of objects be emphasized or that military information, such as that representing the disposition of troops, organization of ground, enemy, or friendly works, supply and circulation activities, be recorded by some means without unnecessarily damaging the print. This difficulty is overcome by means of overlays of high-transparency paper. A light, tough, almost colorless tracing vellum is most suitable for this work, yet any kind of transparent tracing paper which will take pencil and ink marks will answer the purpose.

b. The overlay should be cut to fit the photograph and then carefully registered to the photograph by tracing by means of collimating marks. The serial number of the photograph should always be traced in. Significant marginal information on the photograph should also appear on the margin of the overlay. The overlay should be fastened temporarily to the photograph along one edge to permit the overlay to be lifted for direct examination of detail without disturbing the relation of overlay to photograph. (All photographs destined for extensive use should first be mounted with rubber cement on sheets of stiff manila or similar paper cut slightly larger than the photograph and the overlay tacked to the mount.)

c. Figure 6 represents a mounted photograph equipped as explained with an overlay to receive data.

■ 13. STEREOSCOPY.—An individual aerial photograph gives only two dimensions, length and breadth. However, when two photographs made of the same area at the same scale from

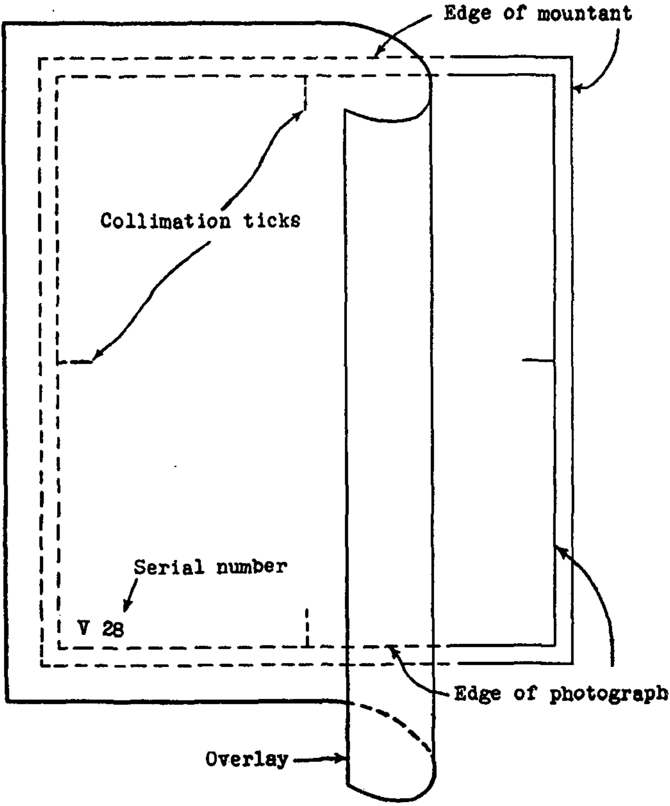


FIGURE 6.—Registered overlay.

different points in space are viewed with an instrument that permits each eye to see only one photograph, a fused image having length, breadth, and depth (height) is registered in the brain. Sixty percent overlap results in images separated

the same distance as the average human eye (64-mm) and gives a normal stereoscopic effect. (See figs. 7 and 8.)

■ 14. STEREOSCOPE.—A stereoscope is an instrument used to obtain stereoscopic effect while viewing photographs.

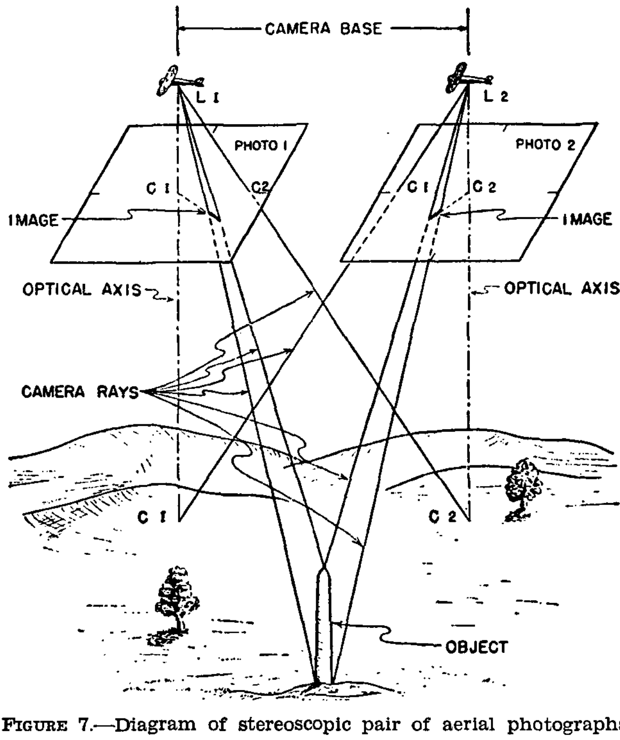


FIGURE 7.—Diagram of stereoscopic pair of aerial photographs.

■ 15. PIN POINTS.—*a.* Two or more stereoscopic vertical aerial photographs of an isolated object or spot are called a *pin point.*

b. Airdromes, supply depots, dumps, road crossings, bridges, defiles, or other bottlenecks on lines of communication requiring detailed study are suitable objects for pin-point photography. They are used with objective folders to show the

location and construction of targets for air attack whenever possible. (See FM 1–10 and FM 1–40.)

■ 16. STEREOSCOPIC EXAMINATION OF PIN POINTS.—When a detailed study of an object of limited area is to be undertaken,

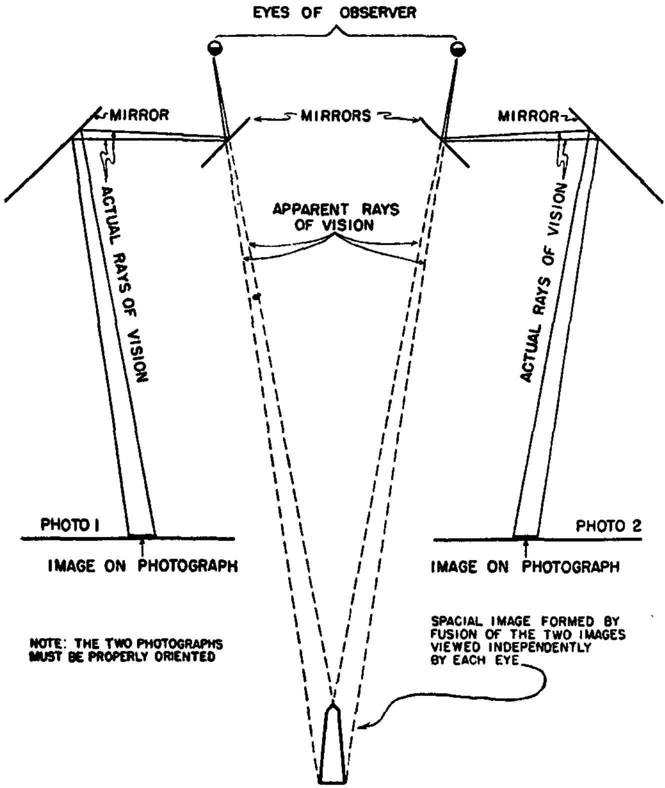


FIGURE 8.—Diagram showing stereoscopic perception.

steroscopic pairs are habitually required. Any two overlapping photographs in a reconnaissance strip constitute a pin point.

■ 17. RECONNAISSANCE STRIPS.—*a*. A reconnaissance strip is a series of overlapping vertical photographs made from an airplane flying a selected course. Vertical photographs are usually taken in such strips with a constant overlapping of 60 percent between the successive exposures forming the strip.

b. Such a strip is used to secure information regarding the condition of or activity along a more or less extended but narrow section of terrain, such as a road, railroad, stream, avenue of approach, or stabilized front line. Photographs from reconnaissance strips are usually studied without making a permanent assembly. They are arranged in their relative order and selected pairs are studied by means of the stereoscope.

■ 18. OBLIQUE STRIPS.—Oblique photographs may be made in similar fashion with a consistent overlapping of approximately 60 percent between successive pictures. When oblique mounts are installed in reconnaissance type airplanes it is practicable to secure both vertical and oblique reconnaissance strips on the same flight.

■ 19. MOSAICS.—*a*. A mosaic is a picture that is formed by joining several overlapping vertical photographs taken at different camera positions. The term is generally applied to an assembly of two or more overlapping reconnaissance strips. When the several photographs are oriented by matching the detail along their borders, the result is an *uncontrolled mosaic*. This provides a good pictorial representation of the ground but will have errors in scale and azimuth. Several methods of rapidly assembling uncontrolled mosaics are listed in paragraph 103. When the several photographs are brought to a uniform scale, oriented with respect to one another and fitted to points of ground control, the result is a *controlled mosaic*. The relative accuracy of a controlled mosaic when used as a map is in proportion to the quality of the photographs and to the degree of care used in its preparation.

b. The term "mosaic" is reserved for the assembly of photographs covering the area. When photographs covering an area are not assembled but are used for intelligence purposes it is customary to refer to them as reconnaissance strips. Photographs made primarily for assembly into a mosaic may

be exploited and interpreted by simple visual study or by stereoscopic study.

c. Mosaics which carry such marginal information as is applicable, a military grid, and a limited amount of descriptive matter are termed "photomaps." They may be reproduced readily in quantity by lithography.

d. Uncontrolled mosaics may be used as situation or operations maps when time does not permit the construction of more satisfactory maps.

■ 20. STRIP MOSAICS.—*a*. When the several photographs of a single strip are joined together or mounted to form a mosaic the result is a *strip mosaic*.

b. Strip mosaics may be used as a map substitute for air units penetrating hostile territory which is inadequately mapped.

■ 21. TYPE PHOTOGRAPHY TO BE USED.—The decision as to whether to secure pin points, reconnaissance strips, multiple-lens composites, or mosaics depends on the area to be photographed and the scale desired. The scale chosen will depend upon the desired size of the image to be studied. Pin points are used whenever scale and area to be covered permit because of the great savings in laboratory processing. When the area is so extensive that it cannot be adequately covered with one or two pin points, then composites, reconnaissance strips, or mosaics are used.

CHAPTER

UTILIZATION OF AERIAL PHOTOGRAPHS

SECTION I

GENERAL

■ 22. CLASSIFICATION.—*a*. Military aerial photography is divided by its tactical employment and equipment into two general classes:

(1) Aerial photography for mapping (photographic mapping).

(2) Aerial photography for military information (photographic reconnaissance).

b. While these classifications apply generally to all operations, there are times when photographs made for mapping are used for intelligence purposes, and conversely when reconnaissance photographs are used for mapping purposes.

■ 23. MAPPING PHOTOGRAPHY.—*a*. Aerial mapping photography is a relatively inexpensive means of securing accurate data for the construction of military maps. This may be accomplished by means of a series of overlapping single or multiple-lens photographs. Regardless of which type camera is used for mapping, the flight procedure is the same, that is, the systematic flying of parallel courses at such intervals as will insure adequate coverage of the area. It is desirable that mapping photography be accomplished from as high an altitude as weather conditions and operating equipment permit.

b. The negatives and two prints from each are delivered to the topographic engineers for map construction or correction purposes.

■ 24. PHOTOMAPS (AR 300–15, FM 30–20, and *TM 1–220).—*a*. The usual form of photomap is the lithographic reproduction of a mosaic of many overlapping vertical photographs carefully assembled to some form of ground control. However, a photomap may be made from any vertical or composite photograph.

b. For marginal data to be shown on all photomaps see AR 300–15.

■ 25. WEATHER REQUIRED.—Excellent weather is required for obtaining best results in mapping photography. It is, therefore, requisite that the need for mapping photography be anticipated in order that advantage may be taken of accurate favorable weather conditions.

■ 26. RECONNAISSANCE PHOTOGRAPHY.—*a*. Aerial photography is one of the principal means for securing information of hostile activity in rear areas. The camera is a valuable accessory for every aerial observer and is carried habitually on all reconnaissance missions whenever the type of aircraft permits. The photographs used by intelligence sections may be made by any of the standard cameras, but the multiple-lens camera is not generally used because of the length of time required in processing.

b. The vertical is frequently the most satisfactory type of photograph for reconnaissance purposes. When weather or other conditions prevent the taking of verticals, oblique photographs can often be substituted. Obliques will frequently prove of greater value than verticals, particularly in locating objects under cover of woods, facilitating a correct understanding of relief, and revealing breaks and gaps not visible on vertical photographs. Oblique photographs when studied with verticals of the same area are more readily exploited.

SECTION II

UTILIZATION BY GROUND FORCES

■ 27. GENERAL.—Aerial photographs are of value to all command echelons of ground forces. Some specific applications are given in the following paragraphs.

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*See appendix II.

■ 28. THEATER OF OPERATIONS.—Prior to the movement of a ground force into a theater of operations, the entire area may be mapped by aerial photography if existing maps are inadequate. Even though adequately mapped, this area should be rephotographed, if the situation permits, to obtain the latest information of natural cover and lines of communication. Obliques should be made of all critical points in the lines of communication, such as bridges, railway junctions, highway centers, and passes.

■ 29. LANDING OPERATIONS.—Whenever a landing is contemplated on a hostile shore, photographs of all proposed beach heads must be secured to permit intelligent planning. One or more reconnaissance strips are desirable for this type of operation; however, oblique strips may be substituted therefor.

■ 30. RIVER CROSSING.—Just prior to initiation of an anticipated river crossing, one or more reconnaissance strips should be made of the stream. Both banks of the stream should be covered to a depth of at least 500 yards. Unless the water is very muddy, sand bars and underwater obstructions will probably be indicated. Bridges, ferry slips, and rough water will be readily apparent. The nature of the banks and stage of the river will be indicated. Fordable portions of the stream may frequently be indicated from a careful study of the aerial reconnaissance photographs.

■ 31. FORCES IN CONTACT.—*a.* Supported ground forces will desire aerial photographs of installations and activities whenever ground forces are in contact. When weather conditions or enemy interference does not permit obtaining verticals, oblique photographs are secured.

b. Large scale stereoscopic pin points are made for a study of suspected locations of artillery, reserves, command posts, and other enemy installations.

c. Visualization of the terrain over which troops are to advance is best facilitated by the use of high oblique photographs. High obliques are also useful to artillerymen and to balloon observers.

d. Details of construction of bridges which will become targets for artillery fire are best revealed in low obliques.

e. Details of organized positions are best revealed by coordinate study of vertical and oblique photographs of the position.

f. The location of front lines may be determined by either vertical or oblique photographs if natural cover is not too heavy. Panels are generally visible in vertical photographs made from altitudes up to approximately 5,000 feet.

■ 32. ROADS.—*a*. Visual reconnaissance is the most rapid means of examining roads. When large columns of vehicles or troops are observed, either oblique or vertical photographs provide the simplest means for accurately recording the composition and strength of the columns.

b. Night photographs are of great value in securing information of the presence and nature of traffic on roads at night.

■ 33. FORTIFICATIONS.—Fortifications should be studied by means of aerial photographs. It is generally preferable to use a reconnaissance strip or strips to cover the zone of fortification.

■ 34. CHANGES.—Photographs of effect of fire, of construction or organized positions, and of establishment of supply dumps and artillery positions are compared with the previous aerial photographs to determine the changes that have occurred. The successive photographs should present the same aspect of the area involved.

SECTION III

UTILIZATION BY AIR FORCES

■ 35. GENERAL.—Aerial photographs may be used by air forces in many different ways to assist the commander in the preparation for and execution of various missions. Some of these methods are listed in the following paragraphs.

■ 36. VISUAL RECONNAISSANCE.—Aerial photographs will be used frequently during the conduct of visual reconnaissance missions for the purpose of recording observations; for example, the number and type of vessels or vehicles in a convoy, the number and type of aircraft in a formation, and descrip-

tion of hostile airdromes, including the presence or absence of aircraft thereon. In many of the illustrations used above the information will be of such character that it must be immediately reported by some means of signal communication to the interested commander. The purpose of securing photographs under these conditions is to verify and amplify the information reported.

■ 37. STRIKING FORCE OBJECTIVES.—Aerial photographs are used to locate and develop objectives and will invariably be included in the objective folder. Aerial photographs will frequently record the effects of air attacks.

■ 38. OTHER INSTALLATIONS.—Airdromes, supply establishments, industrial areas, and similar objectives should be photographed so as to permit stereoscopic study. In photographing airdromes some of the surrounding terrain should be included for study of the presence and dispersion of aircraft and facilities.

■ 39. ANTIAIRCRAFT DEFENSES.—Aerial photographs are used for the location of and detection of the nature of antiaircraft defenses.

■ 40. AID TO NAVIGATION.—Aerial photographs are used to acquaint flight personnel with the appearance and nature of the terrain along the route to or from objectives. This may be accomplished by means of a photographic reconnaissance strip without forewarning hostile forces. Aerial photographs of the area about and including an objective are of particular value to reconnaissance personnel who are charged with illumination of targets for night attack.

■ 41. SELECTION OF AIRDROMES.—Aerial photography can be used to assist in determining suitable location of airdromes and supply installations in a new theater of operations.

■ 42. CONCEALMENT AND CAMOUFLAGE.—Aerial photographs are furnished camouflage officers for determining the adequacy of concealment of troops and installations. The adequacy of camouflage of airdromes, landing fields, aircraft, supply installations, antiaircraft defenses, and other friendly activities will be verified frequently by means of aerial photography.

SECTION IV

PRACTICAL LIMITATIONS

■ 43. FACTORS.—*a.* The uses to which aerial photographs may be put depend to some extent upon the technical quality of the photograph.

b. This quality in turn is dependent upon the following:

(1) Characteristics of the equipment.

(2) Ability of the cameraman.

(3) Ability of the pilot.

(4) Ability of the laboratory personnel.

(5) Light conditions.

(6) Weather.

c. The effect of the first four limiting factors can be greatly reduced by correct indoctrination in employment and by thorough training of personnel. The effect of the fifth limitation, light conditions, may be reduced to some extent by instruction. For instance, proper instruction will prohibit the ordering of early morning or late afternoon mapping missions unless required by the tactical situation.

■ 44. WEATHER.—*a.* Weather is the dominant factor limiting the quality of aerial photographs. Aerial photography of objectives covered by fog or clouds is impractical. In general, clouds reduce in some degree the quality that would otherwise prevail. Similarly, any obstruction to vision, such as dust, smoke, haze, or precipitation, reduces photographic quality.

b. Filters may be used to overcome some of the handicaps of dust, smoke, and haze.

■ 45. TRAINED PERSONNEL.—*a.* An aerial photographer is trained to select and manipulate the available equipment in order to produce photographs of high quality despite adverse visibility conditions. However, an aerial photographer should be consulted when preparing requirements for a mission to avoid unnecessarily rigid specifications. The photographic crew should thoroughly understand the need and the basic requirements of the aerial photographs desired. At least one member of each crew performing photographic missions at a distance from the base should be a thoroughly trained aerial photographer.

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b. Success or failure of any photographic mission hinges upon the efficiency of personnel performing any one of nine separate operations.

■ 46. Time Factor.—The processes of photography all require time for their accomplishment. Time is required for each of the several steps of processing negatives and prints as well as for the mechanics of preparing for, performance of, and return from the aerial mission. The supported unit which uses the photographs, the airdrome, and the photographic laboratory may be separated by such distances as will involve a loss of time. This time factor must be considered by all who request aerial photographs. The time factor is contingent on many variables and can be definitely determined only by units concerned.

Section V

DIRECTIVES FOR PHOTOGRAPHY

■ 47. What and When to Photograph.—*a*. The supported unit will decide, as a general rule, what will be photographed and when the photography will be accomplished.

(1) The "what" as used above refers to an area or an objective or a class of objects.

(2) The "when" is used to indicate either exact or approximate time, as a mapping mission may be scheduled for as soon as weather permits, a photographic reconnaissance for early morning, late afternoon, or at 10:00 p. m.

b. This does not prohibit employment of the camera on visual reconnaissance missions to record information whenever the nature of the mission, time, weather, and equipment permit.

■ 48. How to Photograph.—The Air Corps unit responsible for photographic reconnaissance or mapping missions will decide upon the methods best calculated to insure satisfactory completion of the mission. Consideration is given to the requirements of the supported unit, limitations of equipment, hostile activities, and weather conditions.

■ 49. Requests for Aerial Photography.—*a.* Requests by the supported unit for the accomplishment of aerial photography are forwarded through command channels.

b. Requests for mapping photography will specify the area to be covered, scale, type of camera to be used, limitations on shadows, overlap in direction of flight and between flights, and type of paper required for prints. The prescribed altitude should be held as closely as possible. Frequently altitude variations as little as 100 feet will render the photographs unusable.

c. Requests for intelligence or reconnaissance photography will be made in accordance with the provisions of FM 30–21. The requests may be oral or in writing, and when possible should specify the following:

(1) Map areas to be photographed. When possible this area should be accurately delimited on a map, photograph, or overlay. The tendency to include a larger area than that needed imposes an unnecessary burden upon both flying and laboratory personnel, and utilizes valuable and limited facilities to no advantage.

(2) Type of photograph—oblique or vertical.

(*a*) High or low oblique and elevation and direction at which it is to be taken.

(*b*) Scale of vertical desired (small, medium, or large). The scale may be varied if weather conditions, enemy activity, or other causes render impossible the securing of the scale specified.

(3) Purpose for which desired. This means the exact and not the general purpose and must be supplied in order that the crew performing the mission may understand the requirements, and thus be able to decide upon alternatives applicable under adverse conditions. For example, request will state, "To locate machine gun emplacements in the vicinity of *X*," "To study the organization of the ground," "To select an airdrome," "To verify concealment of troops," etc., rather than "Photographic reconnaissance."

(4) Time photographs would be taken.

(5) Number of copies desired and time and place of delivery.

(6) Unless otherwise stated, reconnaissance photography is accomplished by producing single-lens vertical photographs

with a 60 percent overlap between successive exposures in a strip, and 40 percent overlap between adjacent strips in the event that two or more strips are required. If the scale of the photograph desired is not specified, photographs will be secured at a scale of 1:5,000, provided conditions of weather and enemy activity permit.

■ 50. Dual Purpose.—Mapping photography is performed at high altitude with a wide coverage camera to permit photographing of extensive areas in a minimum length of time and with the least number of pictures at a scale consistent with the proper delineation of the terrain. Mapping photography should not be confused with intelligence purposes because of small scale and lack of detail. However, mapping photography, even though on small scale and especially when taken over enemy terrain, may contain important information, and prints of all mapping photography should be made available to military intelligence officers for study. On the other hand, photographs taken for intelligence purposes may be useful in mapping, primarily in revision, and their use may obviate the necessity for sending special photographic missions over enemy territory.

■ 51. Coordination With Engineers.—The relationship of the Air Corps to the Corps of Engineers with regard to aerial photography is set forth in AR 300–15 and FM 30–20. These regulations provide that the Air Corps will perform the photography required by the Corps of Engineers in accordance with specifications prepared by the engineers, and that the negatives and necessary prints will be delivered for use in preparing maps. Photography for use in photogrammetric mapping is prescribed in paragraph 50. In addition to this photography, corps topographic companies will need wide coverage, small-scale photographs for use in preparing map substitutes. This photography is similar in nature to intelligence photography. The commanding officer of an organization to which Air Corps units are assigned or attached will, through the assistant chief of staff, G–2, coordinate requests for aerial photographs emanating from ground troops, including topographic engineers, and will coordinate photographic missions of his own and subordinate units.

CHAPTER 3

OPERATIONS

SECTION I

AIR CORPS FUNCTION RELATING TO AERIAL PHOTOGRAPHY

■ 52. GENERAL.—*a*. It is a function of the Air Corps to perform all types of tactical aerial photography and to deliver as soon after the exposure as possible a limited quantity of the resulting prints or the negative itself to the supported units.

b. All training must emphasize the necessity for speed during the several steps in processing while maintaining a high technical quality of the finished product. A photographic mission is not completed until the photographs are actually in the hands of the user. Aerial photographs secured at great hazard to personnel and equipment may be rendered valueless if not rapidly processed and delivered. The necessity of reducing to the minimum the elapsed time between the exposure of the negative and the delivery of the print must be appreciated.

■ 53. CLASSES OF AVIATION PERFORMING PHOTOGRAPHY.—The camera is the principal auxiliary of visual aerial reconnaissance; therefore all aviation performing reconnaissance will be equipped with aerial cameras when aircraft design permits. However, the bulk of aerial photography will be performed by that class of aviation primarily organized and equipped to perform reconnaissance.

■ 54. LABORATORY RESTRICTIONS.—Mapping photography is normally of the multiple-lens type and must be processed

under conditions approaching those of a permanent peacetime establishment. The equipment and methods employed in laboratory processing differ materially from those used by units performing reconnaissance or intelligence photography, which utilize the small mobile trailer laboratory.

SECTION II

REQUIREMENTS OF PHOTOGRAPHIC MISSION

■ 55. ORDERS.—Each order directing a photographic mission will include applicable parts of the information specified in paragraph 49. The means and methods of delivery of photographs will be specified in the appropriate operations, field, or administrative order.

■ 56. RECORDS.—An accurate record must be maintained by either the pilot or cameraman, or in part by each, in order that the information required by FM 30–21 may be placed upon the negatives. Also, record must be kept of the order in which the area is covered. When aircraft space permits, it is desirable that other members of the crew keep records of the data that must otherwise be maintained by the cameraman.

■ 57. OVERLAP.—*a*. Unless otherwise stated, all vertical aerial overlapping photographs will be made with 60-percent overlap in direction of flight. This amount of overlap insures coverage if for any reason one exposure cannot be used and also gives a normal relief when successive photographs of a strip are viewed through a stereoscope.

b. Adjacent strips will normally overlap 40 percent when made for mapping and usually for reconnaissance photography. This depends, however, upon the situation, as a photographic reconnaissance of a river might be performed well by flying a strip centered over each bank with overlap varying from 50 to 10 percent as the river changed its width.

■ 58. TILT.—Mapping photographs will be made with the axis of the camera lens within 1½° of the vertical.

■ 59. NAVIGATION.—Accurate navigational equipment and methods are required for the satisfactory accomplishment of

vertical photographic missions, and special instruments may frequently be needed when flying on mapping photographic missions.

■ 60. MAPS.—*a*. When maps are available, the trace of flight lines will be computed and transcribed if the mission involves vertical photography. Methods of determining spacing of the flight line are outlined in *TM 1–220. When the mission is to be performed at some distance from the airdrome and weather conditions and enemy activity cannot be acccurately determined, it is more desirable to carry templates showing the spacing of flight lines at each of several altitudes. The template for the altitude finally selected can then be superimposed upon the map and the trace of the flight line upon the ground determined.

b. When maps or map substitutes are not available, one or more of several methods may be applied to locate flight lines.

(1) Navigational methods that are used for dead reckoning courses are applicable to the photographic mapping of an area. A drift sight is required for satisfactory accomplishment.

(2) Having determined the course for the first flight line, it is practicable to use an alidade and sketch board to assist in determination of the adjacent flight line. Some member of the crew adjusts the sketch board to give a line of sight that intersects the ground at the trace of the next flight line, and using the alidade sketches its relationship to peculiarities of terrain, such as lakes, bends in streams, clearings, and roads.

(3) A formation of photographic airplanes may take up the correct interval while over familiar terrain and continue on the same heading over the area to be mapped.

■ 61. WEATHER.—*a*. Eliminating for the moment the effect of enemy activity, weather is the dominant limiting factor of aerial photography. In dispatching photographic missions, consideration must be given to the weather conditions forecast for the area to be photograhed. Existing weather condi-

*See appendix II.

tions will be considered when known. Present systems of indicating weather conditions are not sufficiently specific for efficient photographic operations. To illustrate, a correctly reported unlimited ceiling with high overcast may mean clouds at or below the level at which it is necessary to operate. Scattered clouds may or may not interfere with mapping photography. Ground cover—snow—is rarely indicated. The above illustrated conditions adversely affect photographic mapping to a greater extent than they do photographic reconnaissance.

b. It is possible to make aerial photographs of some military value whenever it is practical to fly contact without sole reliance upon instruments.

■ 62. SECONDARY OBJECTIVES.—When a large area or widely separated areas are to be photographically mapped, each crew ordered on photographic missions will be equipped with maps and necessary data for more than one mission or area. Experience has shown that when objectives are separated by as little as 50 miles there are many occasions when one may be photographed while the other is obscured by clouds. The same consideration applies to photographic reconnaissance, particularly of air attack objectives.

■ 63. SECURITY.—*a.* Aerial photographic mapping normally will be performed under excellent weather conditions, and the performance of the mission may become difficult if operating over defended areas. Flight just below the service ceiling of the photographic aircraft will permit the maximum coverage with each exposure. This increases the flight line interval to several miles and when combined with long flight lines will be less noticeable to ground observers.

b. Aerial photographic reconnaissance frequently requires that photographs be made of defended areas. In planning this type of mission special consideration must be given to security. The actions taken to insure the return of the aircraft with the information desired will, of course, depend upon the situation and cannot be covered in detail.

(1) Aircraft operated singly are neither as noticeable nor as profitable a target as formations of aircraft.

(2) (*a*) A wide range of altitudes is offered to a photographic crew by judicious selection of the camera or cameras having the focal length to give the required scale.

(*b*) Every effort consistent with the security of the mission should be used to secure the scale requested. By the use of the 6-inch, 8¼-inch, 12-inch, or 24-inch focal length cameras this scale should be secured without operating in the area of most effective ground defensive fire.

(3) Broken cumulo-stratus clouds may act as a barrier to successful vertical photography, but may be used as a shield for oblique photography if the photographic airplane drops just below the clouds in order to make the exposure and retires into or above them between exposures.

(4) Satisfactory oblique photographs may be made from aircraft flying just above the ground, provided that the cameraman is alert and familiar with the objective to be photographed.

(5) Photographic airplanes will operate generally as high as cloud conditions and the nature of the missions permit, and will use the longer focal length cameras in order to secure an image of adequate size.

(6) Photographs may be made from one or more airplanes flying in formation for purposes of security against fighter aircraft.

■ 64. VERTICAL VERSUS OBLIQUE PHOTOGRAPHY.—Verticals are frequently superior to oblique photographs, especially when the details contained thereon are to be transferred to a map, because the scale is approximately uniform on any individual photograph and data are more accurately transferred to a map. Whenever weather conditions or enemy activity makes vertical photography impracticable, an oblique, either high or low, will be made of the area desired. This, however, means that the aircraft will be operated at a lower altitude, and invariably the enemy will be aware of photographic activity.

■ 65. OBLIQUE PHOTOGRAPHY.—For intelligence purposes obliques are frequently superior to verticals, especially for wooded or covered areas. In situations where it is believed that the enemy has made extensive use of camouflage, oblique

photographs, when compared with vertical photographs and other obliques of the same area, will be of great assistance in detecting installations and fortifications.

■ 66. QUANTITY.—The quantity of aerial photographs required for intelligence purposes will be as prescribed in FM 30–21. In specifying the number to be printed, the limited capacity of the mobile laboratory will be borne in mind. Upon the successful completion of a photographic mission, the photographic negatives are developed immediately and two prints of each negative, except those made exclusively for mapping purposes, are made and sent to the squadron intelligence officer. The squadron intelligence officer, assisted by the observer who made the flight, and the intelligence liaison officer from the corps or army, if present, study these prints for information of immediate importance, which is transmitted to the headquarters of the unit concerned by the most rapid means of communication available. These prints then become a part of the observer's report, and the total number of additional prints prescribed will be printed by the squadron.

■ 67. DISTRIBUTION OF AERIAL PHOTOGRAPHS.—*a*. When the photographs are received in the intelligence section of the supported unit they are evaluated and interpreted in the same manner as other information. But few additional prints will be needed for strictly intelligence purposes. When a large number of prints are required by lower echelons of command for use as maps, to visualize enemy terrain, formations, or fortifications, the engineer reproduction unit will be required to furnish the specified number of copies either lithographically or by the rapid multiple-contact printer.

b. The additional photographic prints required for objective folders or to orient flying personnel operating over unfamiliar terrain will be provided by the photographic laboratory.

■ 68. AERIAL PHOTOGRAPHIC EQUIPMENT.—*a*. The camera equipment is a part of the airplane and will be available at all times for use in the airplane unless undergoing inspection or repair. This inspection and repair will take place in the vicinity of the airdrome, not necessarily at the photographic

laboratory. Present equipment in the way of magazine or film holders permits the transfer of film, whether exposed or unexposed, from the laboratory to the airplane, or vice versa, without requiring special means of transportation. Any type of vehicle is sufficient to transport a magazine or film holder from the airplane to the laboratory.

b. When the photographic laboratory is not conveniently located with reference to the airdrome, it is practical to drop the film magazine by parachute to the laboratory. The cameraman's record of objectives and exposures will be included with the magazine.

■ 69. SUPPLY AND TRANSPORTATION.—It is the responsibility of the commanding officer of the flight unit operating aerial cameras that sufficient quantities of sensitized film are immediately available with which to perform all those missions which may be scheduled within a 24-hour period. He is also responsible for having sufficient quantities of photographic flashlight bombs available for a like period. Transportation must be available to meet landing photographic aircraft and to transfer exposed film to the photographic laboratory for processing in case magazines are not dropped at the laboratory.

SECTION III

PILOTAGE

■ 70. RESPONSIBILITY.—*a*. The commanding officer of the Air Corps unit performing aerial photography is charged with the responsibility of training his combat crews to perform all types of photographic missions which are normally performed with the camera equipment allotted.

b. Aerial photography requires a high degree of coordination between the pilot and the rest of the crew. The pilotage required on any photographic mission is of a precise nature, and especially qualified personnel should be selected whenever practicable.

■ 71. PILOT KNOWLEDGE OF CAMERA.—It is desirable that each pilot expected to perform a photographic mission have some training as a camera operator, in order that he may better realize the field of coverage of the various types of cameras,

the difficulties of securing vertical photographs, and appreciate the need for precision pilotage. Efficiency in flying photographic missions comes only with experience. Each pilot performing this type of mission should be required to check the results of the mission—that is, actually study the photographs with the cameraman who made the exposures.

■ 72. Requirements for Mapping Photography.—Satisfactory results from operation of the mapping camera require that the airplane be flown precisely in azimuth and altitude along a projected flight line. Level altitude of the airplane at all times permits the cameraman to secure vertical photographs with the minimum difficulty. It is not practicable to perform satisfactory mapping photography under conditions of rough air or from an airplane lacking stability. A high degree of coordination is required between the cameraman and the pilot in order to insure exposures at the proper instants.

■ 73. Level Flight.—*a.* Maintaining the airplane level laterally and simultaneously adhering to the required altitude is a difficult task even under favorable conditions. This becomes further complicated when it is necessary to follow a precise path over the ground. It has been found that level flight may be maintained best by using the visible horizon as a reference. Before attempting to follow a given flight line, the pilot must be thoroughly familiar with its trace on the ground and be oriented with relation to it. It should be unnecessary to refer to a map while following the flight line. Before starting down the flight line the airplane should be trimmed to fly level. The altitude can be maintained only by frequently observing the altimeter reading.

b. Under visibility conditions of approximately 25 miles or less, maintenance of the flight path by means of instruments and ground reference is more practical. The visibility distance required will vary with airplane speed and individuals. However, this will not result in as level an airplane as when the clearly visible horizon is available for reference.

c. Whenever the airplane gets out of proper alinement, corrections should be effected immediately but gradually. Whether this correction be one of tilting the airplane about

any of its axes or of changing altitude, return to the normal flight path should be gradually effected. The sudden checking of any motion of the aircraft displaces the spirit level and the camera to such an extent as to render vertical photography difficult. A slight bank or a slow turn will cause less displacement of the camera spirit level than will an abrupt correction.

■ 74. AUTOMATIC PILOT.—The use of an automatic pilot to fly the aircraft is not recommended during the actual time of photography. The sudden checking of displacements of the aircraft from the normal, inherent in automatic pilots, sets up accelerations that render the spirit level reading inaccurate.

■ 75. ALTITUDE.—*a*. Vertical photography is concerned with the actual altitude above the area to be photographed, therefore the indicated altitude used on a given mission must correspond to the desired true altitude.

b. The use of the throttle is recommended as a method of maintaining altitude. If above the desired altitude, the operator reduces the throttle in order that the airplane may return to the correct altitude without materially changing its attitude; if below the desired altitude, the operator increases the throttle.

c. When airplanes normally equipped with two sets of flight controls are used for vertical photography, it will be found that one pilot operating only the elevator control may maintain altitude within a 50-foot variation, while the other pilot maintains a flight path over a predetermined line on the ground and keeps the wings level by reference to the visual horizon.

■ 76. HEADING.—In flying long flight lines the drift may change materially during passage along the flight line. To fly a precise flight path over the ground, it is essential that prompt correction be applied to compensate for every change of drift.

■ 77. OXYGEN.—The use of oxygen whenever flying a photographic mission at 12,000 feet or above will increase visual acuity.

■ 78. EFFECT OF FUTURE CAMERAS.—Whereas at present the five-lens camera, either used singly or in tandem, is the standard topographic camera, future development envisages the employment of a single-lens, wide-angle camera for this purpose. The adoption of such a camera will undoubtedly speed up the laboratory process materially; however, the flight requirement will remain the same, chiefly that the flight path be as nearly precise as possible.

■ 79. RECONNAISSANCE STRIPS.—The technique of flying reconnaissance strips differs in no material way from that required for mapping photography. However, they are frequently flown at lower altitudes, and greater tolerances are permitted in the azimuth and altitude variation of the airplane.

■ 80. SIGNALS AND PROCEDURE.—Verbal signals will be used between pilot and cameraman whenever voice communication is possible. When voice communication fails, visual signals suitable for the aircraft allotted to be used will be prescribed by unit commanders.

a. The following procedure is particularly applicable to mapping photography. It will be used to the extent practicable in all types of missions.

(1) When the aircraft is on the flight-line extension, on correct heading, at correct altitude, with proper trim, and, when conditions permit, at least 3 miles from the boundary of the area, the pilot gives the signal READY. The cameraman acknowledges by repeating "Ready," and then proceeds to determine the camera crab and exposure interval.

(2) As the aircraft passes over the boundary into the area, the pilot gives the command SHOOT. The cameraman acknowledges command by repeating "Shoot," and immediately commences camera operation.

(3) When passing over far boundary the pilot gives the command CUT. The cameraman makes one more exposure and then acknowledges by repeating "Cut."

b. The pilot continues along the flight line extension until sufficiently beyond boundary to permit orientation of aircraft and camera upon the next flight line. Then the above procedure is repeated.

c. The allowance of time or distance for stabilization of the aircraft and camera need not be so great on succeeding strips unless the wind changes or camera adjustments are required.

d. (1) In the event of a malfunction of the camera or if a magazine is exhausted during the "shooting" of a flight line, the cameraman immediately gives the signal CUT.

(2) The pilot acknowledges this by repeating "Cut." The pilot immediately places the aircraft in a turn and marks on the map the place over which the last exposure was made.

(3) If the malfunction is cleared rapidly, the aircraft continues on a 360° turn, and shooting is recommenced on signal without taking interval.

(4) If not cleared by the time a 180° turn is completed, the aircraft proceeds back down the flight line or parallel thereto until the cameraman announces that he is ready to operate again. The crew then proceed as outlined in *a* above.

■ 81. OBLIQUE PHOTOGRAPHY.—*a*. The pilotage of aircraft from which oblique photographs are to be made requires that the pilot have complete understanding of the coverage of the particular camera being employed. He should also understand the perspective normally desired, the effect of lighting upon the objective, and must thoroughly understand the nature of the objective in order that he may place the cameraman in the best position from which to secure a photograph that will portray the information desired. The best camera operator cannot return with satisfactory photographs unless the airplane from which he is working is placed in approximately the correct position. The camera operator must also be on the alert in order to take pictures when the airplane is in a position which permits securing exposures of the desired composition.

b. Pilots are cautioned that the terms "high and low oblique" do not refer to altitude and that orders requiring the oblique may state that obliques are desired from approximately 1,000 feet or 5,000 feet, as the case may be. In general practice, operations orders will merely state the coverage required by each photograph. It is the responsibility of the commander of the mission or of the pilot to determine the

altitude from which the photograph will portray the objective in the manner which will meet the requirements. In connection with the making of oblique photographs particularly, the element of security of the mission must always be borne in mind.

c. The flying for oblique photography requires the utmost in teamwork between pilot and cameraman, as oblique photographs are invariably made from lower altitudes than vertical photographs and the time interval between the approach to and passage by an objective is much less. It is essential that the pilot and the cameraman develop a system of simple signals that will insure the cameraman's operating the camera as soon as the aircraft is in proper position. Furthermore, the cameraman must know what the pilot wishes photographed and be able to recognize the objective when he sees it.

d. Standard procedure for recording the information required to identify aerial photographs is difficult to prescribe for all types of missions. The pilot is charged with locating the objective. He will maintain a record of where photographs were made, either in tabular form or by means of marking maps or overlays. It is essential that combat teams utilize a simple method of recording all data that will be required on the negative. The recording of these data is the responsibility of the pilot and the cameraman. The cameraman alone knows how many exposures were made and the time they were made. As a rule, only the pilot knows the exact location unless a navigator is being used, in which case the navigator may take over the pilot's responsibility for the determination of location of individual photographs. The pilot or navigator knows the direction in which the flight is being made, if vertical, or the direction from which the exposure is made, if oblique. Where aerial photography is used as an aid to reconnaissance on a mission that is primarily visual, the cameraman must be prepared to go into action rapidly and secure the photographs needed with the minimum amount of delay, as it is generally inadvisable to advertise the presence of aircraft by circling an objective.

■ 82. VERSATILITY.—The commanding officer of the unit performing photographic missions should permit his combat crew

considerable latitude in the choice of camera equipment. Every crew must be prepared to perform either vertical or oblique photography as the objective or the weather requires.

SECTION IV

CAMERAMAN

■ 83. CAMERA OPERATOR'S REQUIREMENTS.—*a*. In selecting a cameraman, consideration must be given to the fact that the operation of any type of aerial camera involves working in cramped quarters, usually at low temperatures, while performing precise work that requires concentrated effort. Individuals subject to airsickness should not be selected. The cameraman should be one who has already qualified as a photographer. Aerial cameramen are required to change exposure settings and filters to meet weather and light conditions, as it is impractical to operate at all times with settings determined before take-off.

b. The operation of a camera for a vertical photograph requires more precise work than any other type; however, the physical strain of oblique photography is the greater.

■ 84. PREVIOUS PHOTOGRAPHS.—The cameraman should be familiar with previous photographs made of an objective in order to duplicate the viewpoint and coverage. It is desirable that a print, marked to show the objective which is to be rephotographed, be furnished to the operating crew.

■ 85. RELATION TO PHOTOGRAPHIC LABORATORY.—The securing of maximum quality in aerial photographs requires that aerial cameramen be members of the laboratory section which processes their film. It is desirable that the cameraman pay close attention to the method of processing and the density of the negatives secured in order that he may have the necessary knowledge to correct the exposure used on future missions. It is advantageous to have the photographic laboratory facilities used by any aircraft unit physically situated in the immediate vicinity of the operating airdrome and should be so located whenever practicable.

■ 86. IDENTIFICATION.—It is the responsibility of the combat crew and the commander thereof properly to identify all

negatives turned in by them to the photographic laboratory for processing. It must be emphasized that negatives unidentified are valueless, and that the entire mission is wasted unless these negatives are properly and rapidly identified.

SECTION V

FILTERS

■ 87. FILTERS.—*a*. Filters are used in mapping photography for the purpose of penetrating haze or in order to secure more contrast, or both. (For use of filters see *TM 1–221.)

b. In reconnaissance photography filters perform the same function and, in addition, are used to reveal camouflage. Materials may be colored to blend visually with surroundings, but their reflective or absorptive characteristics may be differently shown by the correct use of filters. Enemy installations not apparent in existing photographs but thought to be present may be revealed by additional photographs through a different type of filter.

SECTION VI

COLOR PHOTOGRAPHY

■ 88. DEVELOPMENT.—Color photography is undergoing development, and its place in military photography has not definitely been determined. The laboratory working of color negatives and the making of a transparency are laborious, painstaking, and time-consuming processes. Color photographs give a good rendition of color value when properly exposed. The quality of color photographs is more readily affected by varying light conditions than is that of ordinary black and white photographs. Color photography may play an important part in the interpretation of camouflaged or concealed installations. Delivery of color photographs is restricted to one transparency from each exposure. The using agency will require a transparency viewer in order best to utilize the transparency.

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*See appendix II.

SECTION VII

NIGHT PHOTOGRAPHY

■ 89. TECHNICAL LIMITATIONS.—*a*. Night aerial photographs are limited in area (coverage) and in number because of the following facts:

(1) Altitude from which photographs can be made is restricted to 8,000 feet or less by the limitations of the area that can be illuminated by present photo flash bombs.

(2) The number of photographs that may be made on any individual mission is limited to the number of photo flash bombs that can be carried.

b. Because of the comparatively small coverage of each exposure, night aerial photography is limited by the accuracy of the navigation. The photo flash bomb must be dropped directly above the objective in order to secure the desired photograph.

■ 90. NAVIGATION FOR NIGHT AERIAL PHOTOGRAPHS.—*a*. At night aerial photographs can be made of such objectives as can be located by pilotage or dead reckoning navigation.

b. The coverage of the night photograph exposed at 8,000 feet altitude is about 4,700 feet in the direction of flight and about 5,900 feet across the line of flight. The coverage indicates the allowable errors in azimuth and range which will still permit successful accomplishment of missions to photograph objectives of various sizes.

■ 91. PILOTAGE.—Personnel performing night photographic missions should be thoroughly familiar with the area of the objective when it is to be located by pilotage.

■ 92. DEAD RECKONING NAVIGATION.—Dead reckoning may be required for determination of time of release of the photo flash bomb.

a. For accurate dead reckoning navigation approach to a night photo objective, there must be a clearly defined initial point within a few miles.

b. If this initial point lies within friendly territory it may be marked by an artificial light, that is, a signal light.

c. If there is no natural feature, such as a waterway or mountain, then it may be necessary to define the course by

projecting it rearward from the initial point, and at a point a known distance to the rear to fix another line or beacon. The two course beacons must both be visible at the same time to a pilot flying at the altitude from which the photographs will be made and sufficiently to the rear to enable him to achieve stability of the aircraft in both azimuth and altitude. That is, drift and heading will be determined prior to passing over the first beacon. Ground speed will be determined by the time and distance between beacons. It is evident from the above that the computation of distance between lines must be accurate and that great accuracy must be observed in clocking the flight of the airplane between the two beacons in order that the range or distance to run to the target may be accurately determined.

d. If a highway or railroad is the objective, the probabilities of securing a photograph are increased by flying across the highway or railroad at an acute angle rather than parallel to its length.

■ 93. FORMATION.—Small formations may be used to photograph areas difficult to locate during darkness. Only one flashlight bomb would be released for a formation of three or four airplanes. For larger formations more bombs will be required.

■ 94. PHOTOGRAPHY OF AIR ATTACK RESULTS.—Photographs of the results of a night air attack may be made from one or more airplanes of the attack formation.

CHAPTER 4

PHOTOGRAPHIC LABORATORY

SECTION I

CLASSIFICATION

■ 95. CLASSIFICATION.—Laboratories may be either fixed, mobile, or portable.

a. A fixed photographic laboratory is one housed in a building especially designed for that purpose with permanently installed equipment. Fixed laboratories are not commonly used except in rear areas.

b. A mobile photographic laboratory is installed in a truck, trailer, or similar mobile unit.

c. A portable photographic laboratory is one consisting of equipment which is compact and readily portable, that may be operated in portable tent darkrooms, or installed in improvised darkrooms. Darkrooms may be improvised or constructed in any type of building or cellar capable of being made light-tight and in which the necessary utilities may be installed.

SECTION II

LOCATION

■ 96. UTILITIES.—The fundamental requirements for a photographic laboratory are electricity and water.

a. Electricity may be provided by small gasoline generator units. However, where possible, full utilization is made of locally available electrical power supply. Any fluctuation in the voltage of the power furnished will increase the difficulty of making evenly matched prints. This may be overcome by the use of motor generator units as the final power supply.

b. Water may be secured by pumping directly from a stream or other source, by transporting in tank trucks, or by attachment to a public waterworks system. Pure water gives the best results. However, some types of contaminated water, while not affecting the quality of the print, decrease the life of the developing solution. When necessary, distilling units may be obtained. Mud and sediment may be eliminated in settling tanks or basins.

■ 97. CONCEALMENT AND SECURITY.—Concealment may be achieved by housing a laboratory in a barn, warehouse, or other buildings or in a wooded area. The advantage of going into the woods (near a stream) should be carefully weighed against the vulnerability to chemical attacks.

■ 98. SUPPORTED UNIT.—*a*. While it is desirable to be conveniently located with relation to the flight unit, it is more important to be located adjacent to positive and rapid communication with the supported unit that utilizes the photographs. If the photographic laboratory is engaged in photographic mapping, then it should be located as closely as physically practicable, considering other factors, to the laboratory of the engineer topographical unit. However, if the photographic laboratory is performing reconnaissance photography, then it should be located within a reasonable distance of the supported unit. Many objectives will be photographed just prior to darkness, and the film and prints will not be processed until some time after nightfall. It is unwise to place reliance upon the delivery of photographic prints to the supported unit by dropping from an airplane at night. The time limit will normally require delivery of the finished prints before the following day.

b. A photographic laboratory in close proximity to the supported unit facilitates consultation with photographic technicians regarding the quality or photographic characteristics of the prints furnished. By this means it may be determined whether peculiar appearances on the prints are the result of the photographic image or of technical difficulties. Much misunderstanding and delay may be avoided by this procedure.

SECTION III

LABORATORY PROCEDURE

■ 99. ORGANIZATION OF LABORATORY.—Personnel and equipment of the photographic laboratory will be so organized that incoming film will be efficiently and rapidly processed. The functional organization of the laboratory will be designed to receive incoming exposed film and in an orderly manner rapidly produce prints of high photographic quality.

■ 100. ROUTINE.—*a*. Each laboratory requires one or more rarely less than two) small darkrooms for the development and fixation of aerial film. The laboratory commander will learn from the squadron operations when film from photographic missions may be expected at the laboratory and will have the necessary solutions and equipment prepared for negative processing.

b. While film is being processed in a darkroom, the cameraman's record of the mission will be placed either on a clip or in a receptacle in the entrance in order that the identity of the film may not be lost.

c. Stamps will be set at this time for marking of the negative as soon as ready.

d. As soon as the negative is washed and dried, it will be placed on the plotting table and stamped or otherwise marked with the identifying data.

e. Two prints that will meet the topographic engineer requirements are produced from each mapping negative.

f. Two prints having the proper balance between high light and shadow are produced from each reconnaissance negative. When the contrast of the negative or the deficiency in the contrast scale of the printing papers available makes it impracticable to show the required detail in both the high light and shadow with each print, one print is made to show detail in the high light and one to show it in the shadow for each negative. As soon as the prints from any one mission have been completed they are delivered to the supported unit.

g. Negatives are properly indexed and reports furnished to the second and third sections of the staff of the Air Corps unit charged with the responsibility of procuring the photo-

graphs. Maps are prepared showing the area covered by individual photographs.

■ 101. NEGATIVE FILING.—Mobile laboratories do not have sufficient filing space for extensive storage of photographic negatives. Arrangements must be made for the periodical transfer to rear area laboratories for file. Large photographic laboratories will file negatives that come into their hands in such manner that they may be readily reprinted.

■ 102. NUMBER OF PRINTS.—Requirements for prints for intelligence purposes are given in paragraph 66. Uncontrolled mosaics and reconnaissance strips made by the Air Corps are normally not copied or furnished in quantity. Quantity reproduction is a function of the Corps of Engineers.

■ 103. ASSEMBLY.—*a.* Reconnaissance strips and uncontrolled mosaics are assembled by one or more of the following methods:

(1) *Paper clips.*—This is a rapid but temporary means.

(2) *Thumb tacks.*—This is rapid and is permanent as long as undisturbed.

(3) *Stapling* (Hotchkiss or substitute).

(*a*) By stapling to suitable backing.

(*b*) Without the use of backing; that is, by stapling each successive overlapping photograph to the preceding one by at least two staples. This is a rapid means of showing the relationship of one photograph to another. If the edges of the strips are then bound with masking tape, the complete assembly may be loosely rolled and its transportation made simpler.

(4) *Paste.*—By the more permanent but laborious method of attaching the photographs to suitable backing (nonwarping composition board) with gum arabic or paste.

(5) *Tape.*—By the use of masking tape along two edges. This may be facilitated by first using thumb tacks to assemble the prints, then by applying the tape along the edges of the strip and removing thumb tacks.

b. In all of the above-mentioned methods of assembly it is generally desirable to cut away portions of the overlapping photographs and utilize only the central portion of the print.

These methods may be applied by the personnel of the intelligence section of the staff using the pictures or by the photographic laboratory. Determination of which method will actually perform the assembly should be by mutual agreement or by the common commander.

APPENDIX I

GLOSSARY OF TERMS

Aerial photograph.—A picture taken from any kind of aircraft.

Altitude.—On aerial photographs the true elevation above the area photographed or an approximation thereof.

Azimuth.—The bearing of a celestial body measured as an arc on the horizon from the true meridian north or south to the east or west. Abbreviation: *Z*. Abbreviation *Zn* is used when the azimuth is specified to read from north through east to 360°.

Camouflage.—Work done for the purpose of deceiving the enemy as to the existence, nature, or location of matériel, troops, or military works. The importance of camouflage depends, in general, upon the activity and effectiveness of the enemy's air service, although it is important to camouflage against ground observation.

Composite photograph.—The picture that results from the joining of the vertical and the transformed oblique photographs made by a multiple-lens camera.

Coverage.—The area included in any one exposure by an aerial photograph.

Darkroom.—A room from which all light has been excluded. Darkrooms are required for many of the steps of processing.

Evaluation.—The determination of the probable value of information.

Exploitation.—The tactical or strategical analysis of the information obtained from the photograph.

Exposure.—The act of exposing an emulsion-coated film to the light through the mechanics of a camera. An exposure is a silver image resulting from processing film that has been exposed to reflected light in the camera.

Exposure setting.—The amount of time that the shutter of the camera remains open.

Film.—A plastic base upon the surface of which a light-sensitive emulsion has been coated.

Filter.—A transparent medium that modifies the action of light upon the emulsion.

Glossy photograph.—A photograph having a glossy, bright finish.

Heading.—The angular direction of the longitudinal axis of the aircraft with respect to true north; in other words, the course with the drift correction applied. It is true unless otherwise designated.

High oblique.—An oblique that includes the image of the horizon.

Interpretation.—The operation of determining just what the features shown on a vertical photograph really are, or of discovering obscure or hidden features through related visible features.

Low oblique.—An oblique photograph that does not include the image of the horizon.

Magazine.—That portion of the camera that contains film.

Matte paper.—A photographic paper having a rough, dull finish.

Mosaic.—An assembly of several aerial photographs into one picture.

Multiple-lens camera.—An aerial camera in which two or more lenses are fastened in permanent relationship to each other. A multiple-lens camera is in effect two or more single-lens cameras permanently mounted in one assembly.

Negative.—A photographic image with light values reversed.

Oblique aerial photograph.—A picture made when the optical axis of the camera is tilted away from the vertical.

Overlap.—That portion of a photograph common to an adjacent photograph.

Photographic mapping.—Aerial photographs accomplished for the purpose of constructing a map or map substitute.

Photographic reconnaissance.—All military aerial photography accomplished for other than mapping purposes.

Photomap.—An aerial photograph upon which contours or other information commonly found on maps has been placed. It is usually reproduced by lithograph.

Pin point.—A vertical aerial photograph in which the object of interest is centered.

Print.—A photographic positive on paper. Contact print refers to the method of production from the negative. Contact prints are made at a ratio of one to one. The term is used in contradistinction to a projection print. All enlarged and transformed prints are projection prints.

Processing.—The successive steps of securing a permanent silver image on either film or paper by chemical action.

Sensitized film.—Film that is sensitive to light. This is used in contradistinction to developed exposed film which is no longer sensitive to light.

Single-lens camera.—A camera in which only one lens assembly is mounted at one time.

Stereoscope.—An instrument used to obtain stereoscopy while viewing photographs.

Stereoscopy.—The ability to obtain an effect of relief by simultaneously viewing two photographs of an object made from different viewpoints.

Target.—The space within which fire must be placed to accomplish the desired result.

Template.—An opening cut in a sheet of celluloid, plasticele, or cardboard to show the area covered on a map by an aerial photograph. Also, to show the interval between flight lines on a map.

Templet. (*See* Template.)

Tilt.—The angular deviation of the optical axis of the vertical camera from the vertical at the time of exposure. It is measured in degrees.

Topographic engineer unit.—A military organization that prepares, prints, and distributes maps.

Transforming printer.—A photographic printer specially constructed to transform the oblique perspective of an oblique aerial negative to the vertical perspective. The type of transforming printer referred to in this manual is designed to transform negatives having a fixed angle of obliquity.

Transparency.—A positive on film or glass.

Vertical aerial photograph.—One made with the optical axis of the camera at or near the vertical.

Visual reconnaissance.—See FM 1–20.

APPENDIX II

LIST OF REFERENCES

Aerial photography	TM 1–220 (now published as TM 2170–6).
Basic photography	TM 1–221 (now published as TM 2170–5).
Map and aerial photograph reading	FM 21–25 (now published as BFM, vol. I, ch. 5). TM 5–220 (now published as TM 2180–5).
Maps and mapping	AR 300–15.
Role of aerial photography in military intelligence	FM 30–21.
Sketching	FM 21–35.

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